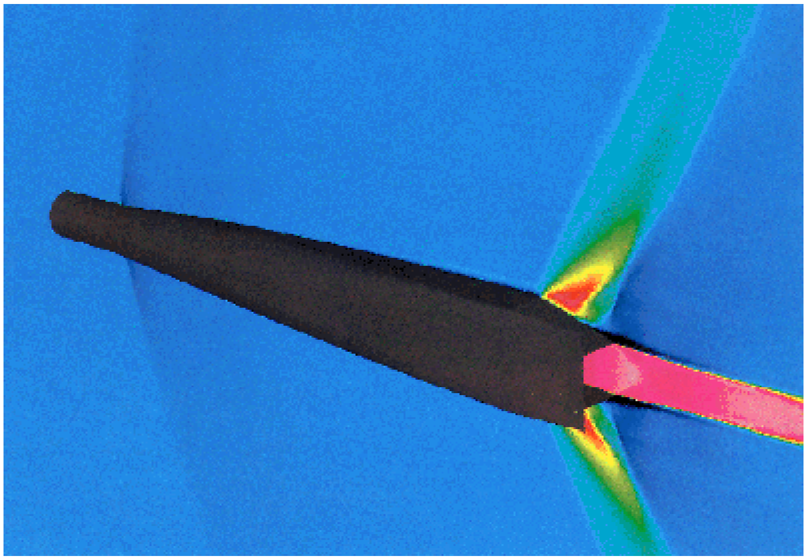
# Prediction Capability for Transonic Nozzle Afterbodies Improved

Under the High Speed Research (HSR) Program, the NASA Lewis Research Center, the NASA Langley Research Center, and the aerospace industry have been developing exhaust nozzle concepts for a future High Speed Civil Transport (HSCT). This 300-passenger aircraft, which is envisioned for the year 2005, would cruise supersonically at speeds of Mach 2.4. For such an aircraft to be both economically viable and environmentally acceptable, the exhaust nozzles must combine highly efficient operation throughout the flight envelope with low noise levels at takeoff.

The initial phase of the HSR Program focused on environmental challenges, with nozzle-related research emphasizing the reduction of takeoff noise. The effort produced nozzle designs that not only meet but surpass HSR noise-reduction goals. The next step in the design process is to address the nozzle's performance throughout the aircraft's mission and integrate it with the rest of the propulsion system. To evaluate nozzle concepts for all flight conditions, engineers rely on empirical data bases obtained through extensive wind tunnel tests. However, the current HSR nozzles are a rectangular (two-dimensional) design, and this type of nozzle is not well represented in the existing data base. Therefore, the current methods for predicting nozzle performance are inadequate. This is especially troublesome at transonic (near Mach 1) conditions where the drag on the nozzle afterbody (boattail) can be as high as 25 percent of the thrust produced.

For a more accurate analysis at transonic speeds, a two-dimensional afterbody data base was needed. Because of the expense, time requirements, and difficulties in testing at these Mach numbers, wind tunnel tests were not feasible. A team composed of researchers from Lewis, Langley, and McDonnell Douglas created a two-dimensional data base using computational fluid dynamics. First, each group validated their computational fluid dynamics code against existing experimental data to gain confidence in the code's results. Next, the organizations analyzed several configurations, and the results were used to create the new data base. Then, the analysis methods were updated to account for the effects of two-dimensional nozzles. This will result in a more accurate analysis of the propulsion system for the High Speed Civil Transport.



*NPARC code prediction of Mach number contours about a transonic nozzle afterbody.*

Researchers at Lewis used the NPARC computational fluid dynamics code in their portion of the analysis. This code is a general-purpose, full Navier-Stokes solver that is supported through a joint effort between Lewis and the Air Force's Arnold Engineering Development Center. The analyses were run on both Lewis' Cray Y-MP and the Aeronautics Consolidated Supercomputing Facility's Cray C-90 located at the NASA Ames Research Center. Lewis produced seven calculations for the data base. Results of the Government-industry team correlated well with each other as well as with the accepted theory.